A direct competitor of the widely used IDE and E-IDE interfaces for hard disks, the SCSI interface still holds its own as an interesting alternative in today's PCs. Whereas an E-IDE interface can only handle up to four disk drives, a SCSI interface easily does up to seven. Wide and Ultrawide SCSI systems even allow 16 devices to be hooked up. Provided you know and respect the 'rules' of the game, you will come to appreciate a SCSI system. One of these rules is the correct termination of the SCSI cables by means of 'terminators'.

Design by A. Köhler

build your own active SCSI terminator

In practice, a major advantage of SCSI over IDE is its greater flexibility as well as the in-built ability to connect external devices. 'Devices' not only means hard disk drives and CD-ROM drives, but also scanners, magneto-optical drives and tapestreamers. Lesser advantages include a lower CPU load and lower resource usage (IRQ and DMA). Speed is also often mentioned but this is now questionable as E-IDE systems have caught up in this respect.

Reflections and terminators

If an electrical pulse is transmitted over a long line, you will note that the pulse has been modified when it 'reaches' the end of the line. The pulse edges will be less steep than at the pulse generator output. This effect is caused by the stray capacitance and inductance distributed along the transmission line.

When a sudden and large change occurs in the cross-sectional area (c.s.a.) of the line, interfering signals are generated due to reflections. To get an idea of what this means, electrical signals may be likened to waves. In this representation, the high signal levels correspond to the wave crests, and the low levels, to the 'low' part of any wave. If such waves hit a solid wall, they are thrown back. In this process, a mixture is created of the original waves and the 'reflected' components.

To electrical signals, the end of a signal line has the same effect as the solid wall on a wave. Parts of the electrical signal are reflected at the end of the line, causing severe degradation of the signal-to-noise ratio of the desired signal. This, in turn, makes it difficult for devices connected to these lines to receive and interpret the relevant data as they should. This problem becomes more annoying as the data rate increases and longer wires (cables) are used. The simple solution in the case of (E-)IDE systems is to vastly reduce the cable length and the number of devices connected to the system. With SCSI systems, these reflections are suppressed by the use of so-called terminators.

A terminator in its simplest form consists of a voltage divider between +5 V and ground, which serves to pull the level on each line to +3.3 V. In SCSI systems, the +5 V supply voltage is available at the TRMPWR (termination power) line. The voltage divider usually consists of a 220-Ω and a 330-Ω resistor connected as shown in **Figure 1**. These resistors may be encapsulated in an array-like pack. Many older SCSI disk drives have 2 to 4 resistor arrays that take the form of plug-in devices for line termination.

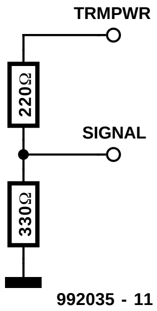

Figure 1. A passive SCSI terminator traditionally consists of a potential divider with a junction voltage of 3.3 V.

This simple method of line termination is not sufficient any more for Fast and Ultra-SCSI systems. In such systems, active terminator devices must be used. In a nutshell, these components are basically voltage regulators that apply a voltage of 2.85 V to each SCSI bus line via a 110-Ω resistor. The key benefit of this type of terminator is its ability to cope with and compensate load variations as they occur with signal changes. In this way, signal reflections are much better suppressed. This active type of line terminator is a must for Ultra-SCSI systems.

An important condition is that both ends of the SCSI cable are correctly terminated. In that case, the cable length is then mainly limited by the capacitive load.

Terminator ICs

As already mentioned, it is possible to build SCSI terminators from their individual components, i.e., a voltage regulator and some resistors. The voltage regulator should then be able to work reliably at a very small voltage difference between its input and output. Besides, it should be able to source as

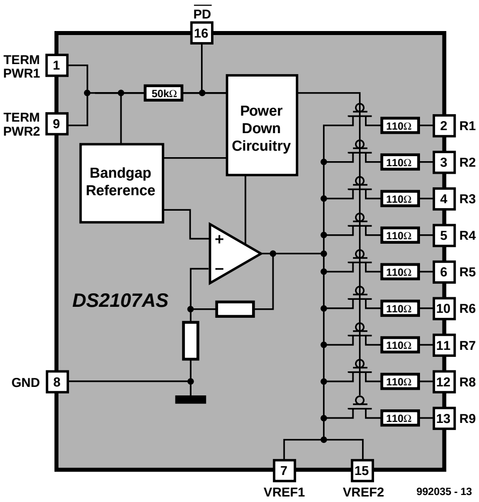

Figure 2. Block diagram of the DS2107 from Dallas Semiconductor.

Table 1. DS2107 pinout

Pin 1	term. pwr	supply line
Pin 2	R1	output to line 1
Pin 3	R2	output to line 2
Pin 4	R3	output to line 3
Pin 5	R4	output to line 4
Pin 6	R5	output to line 5
Pin 7	reference voltage connection 1	
Pin 8	ground	
Pin 9	term. pwr 2	internally connected to pin 1
Pin 10	R6	output to line 6
Pin 11	R7	output to line 7
Pin 12	R8	output to line 8
Pin 13	R9	output to line 9
Pin 14	not connected	
Pin 15	reference voltage connection 2 (connected to pin 7)	
Pin 16	/Power down	low at this pin switches terminator to high-Z state

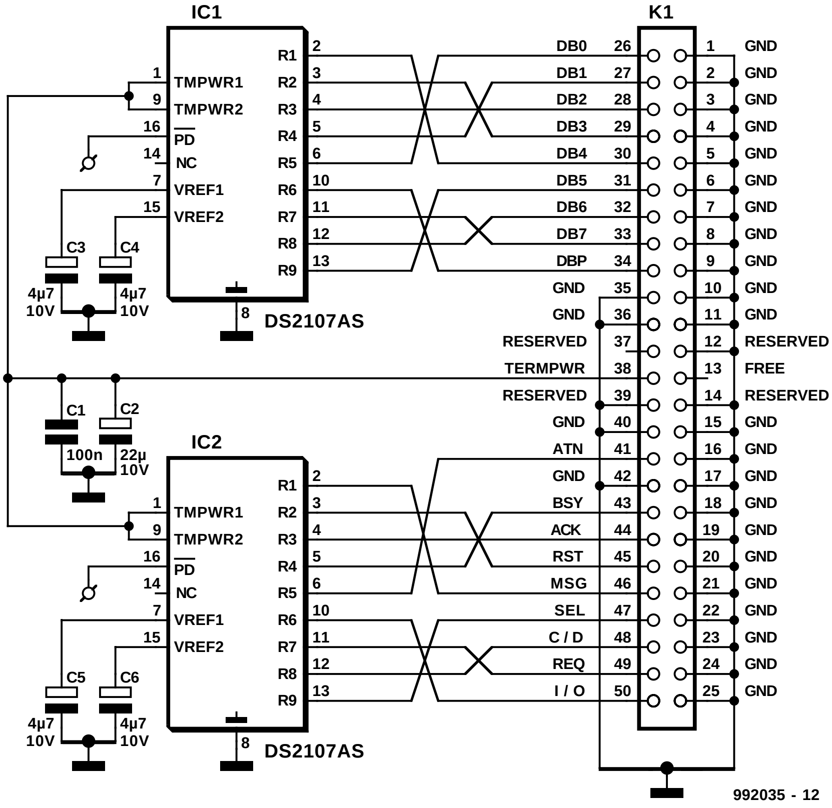

Figure 3. The circuit of the DIY active SCSI terminator consists of two DS2107 ICs.

well as sink current. These conditions considerably restrict the range of available devices.

Not surprisingly, some semiconductor manufacturers have developed dedicated SCSI Terminator ICs, for example, the UC560x from Unitrode, or the DS210x from Dallas Semiconductor. Apart from the simple voltage regulator these ICs also feature protective circuits to deal with short-circuits and thermal overloading. Also available is a control input that allows the device to be switched to a high-impedance (high-Z) state. By fitting or removing a single jumper connected to this pin, the terminator IC may be activated or deactivated. Likewise an I/O component may be employed to control this function in software.

The DS2107

For SCSI-1, SCSI-2, Fast SCSI and Ultra-SCSI, Dallas Semiconductor supplies active terminators types DS2105, DS2107 and DS2109. The first allows up to nine lines to be terminated, the DS2109, up to 18. The present project for home construction is based on the type DS2107. This IC comes in a 16-pin SOIC or a 20-pin TSSOP package. Its pinout is given in **Figure 1**.

Figure 2 illustrates the internal architecture of the chip. All outputs are identical and there is no order of priority. The manufacturer applies laser-trimming to match the internal resistors to a precision of 1%. The output voltage of each individual terminal is 2.85 V. Each terminator line output is capable of supplying up to 24 mA at a ‘low’ level on the relevant line.

A DIY SCSI terminator

Internal SCSI devices (mostly hard disk drives) usually have their own terminators. Traditionally, these may be actuated by means of jumpers found on the drive proper. A (homebrew) terminator is therefore typically used for external SCSI apparatus. The circuit discussed here is a terminator for en external fixed disk mounting frame. The circuit diagram shown in **Figure 3** is heavily based on the application circuit recommended by Dallas Semiconductor.

The connection to the SCSI bus is made by means of a 5-way Centronics-style socket. This is the connector system typically seen on external SCSI devices, even the latest models. The distance between the individual contacts is around 2.16 mm, while the IC pins are spaced at 1.27 mm (0.05 in).

The printed circuit bard designed for this project is single-sided. The copper

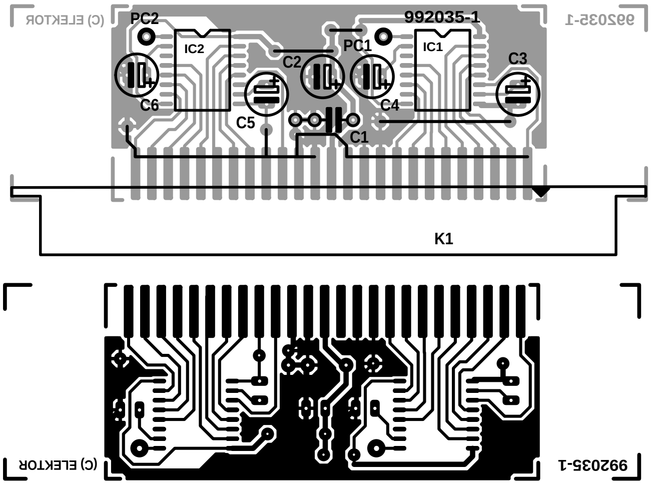

Figure 4. The single-sided board designed for the SCSI terminator. Great care is required in soldering!

COMPONENTS LIST

Capacitors:
C1 = 100nF
C2 = 22µF 10V tantalum bead
C3-C6 = 4µF7 10V tantalum bead

Semiconductors:
IC1,IC2 = DS2107 (Dallas Semiconductor)

Miscellaneous:
50-way socket, IDC (for flatcable connection).

track layout and component mounting plan are given in **Figure 4**. This PCB is not available ready-made through Elektor Electronics' Readers Services. The two SMA (surface-mounted assembly) ICs are carefully soldered to the underside of the board. As shown, the other parts go to the top side. Do not forget the wire links, they are easily overlooked!

One contact row of the 50-way socket (pins 26 through 50) is soldered directly to the tracks at the copper side of the board. As with the SMA ICs, the fine detail of the copper tracks requires a steady hand, a low-power soldering iron with a small bit, and good eyesight. Note that pin 37 is not connected to ground (the copper 'finger' is very close to the ground plane).

The pins that make up the other connector row (pins 1 through 25, except pin 13) are joined with a horizontally running wire which is soldered to ground on the board (see circuit diagram).

If the board is fitted into a metal plug case, great care should be taken to prevent any part or copper track touching the case.

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Literature:

[1] *Product & Applications handbook 1995 – 1996, Unitrode, Merrimack, USA.*

[2] *1998 Short From Catalog, Dallas Semiconductor, Dallas, Texas, USA.*

[3] *SCSI, the ins and outs, Elektor Electronics (Publishing), ISBN 905705-44-0.*